Container Terminal Parameters

A White Paper

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I. Scope of White Paper:

This white paper is prepared by The Cornell Group, Inc. at the request of the Maine Department of Transportation, and provides generic, non-site specific facility, equipment and operations parameters for a small to medium-size container terminal. The assumptions defining the facility and operations design of this terminal are as follows:

- The container terminal and storage areas are developed on a flat, rectangular Greenfield area, unencumbered by uneven topology.
- The berths are constructed along a linear and sheltered coastline.
- The facility has the flexibility to handle container vessels commonly operating in feeder and short sea shipping routes, and direct liner ships in the 6,000 TEU range.
- Berthing capacity allows for simultaneous cargo operations on two large vessels.
- Adequate acreage is provided on the terminal for:
  - Efficient container handling operations with world-class productivity,
  - Container and equipment storage,
  - Warehousing for stripping/stuffing operations,
  - Equipment maintenance, and utilities,
  - Gate operations and security,
  - Truck parking and turnaround areas,
  - Rail yard capable of handling double stack trains,
  - Administration and commercial offices,
  - Land bank for future contingencies

Other factors which determine the size, layout and equipment requirements are specific to each port, and include the cargo forecast, nature of the markets served by the port, and transportation infrastructure supporting the port, among others. While this document does not examine site-specific elements that would affect the size and operations of a generic container terminal, we have nevertheless assumed that (a) the growth in cargo volume at a generic container terminal will be consistent with generally accepted projections for worldwide growth in container traffic, and (b) the terminal would be operated according to the best international practices for similar Greenfield container terminals.

This paper discusses the facility and operational requirements for an efficient, productive Greenfield container terminal based on current world practices. Clearly, any significant changes in the site development assumptions and operating conditions would more than likely increase the space requirements for the terminal. The remainder of this document is organized as follows:

- The next section provides a general description of and operations at a typical, generic container terminal,
- Vessel configurations affecting the terminal size are discussed in section III.

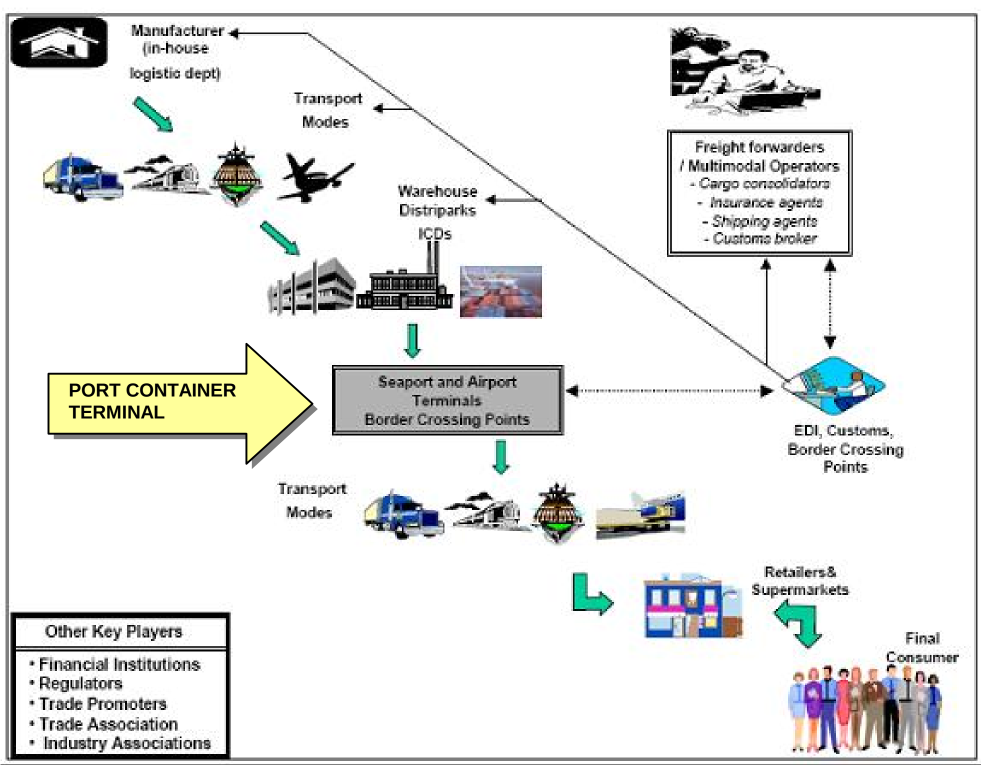
- ❒ Acreages requirements are estimated in section IV.

II. The Container Terminal

A conventional deep-sea cargo terminal is a facility developed along a deep-water coastline to handle the transfer of domestic and international cargo – imports and exports – from ocean-going ships to their final land-side destination(s), or from the originating point(s) inland to the ships. While there are three major categories of cargo – containers, breakbulk and bulk – each with its own particular handling, storage, acreage and terminal design requirements, this paper will focus primarily on terminals designed to handle containerized cargo – the container terminal.

As shown in the following exhibit, the container terminal at a seaport is a critical link in the logistics chain, by means of which manufactured products are delivered to the final consumer.

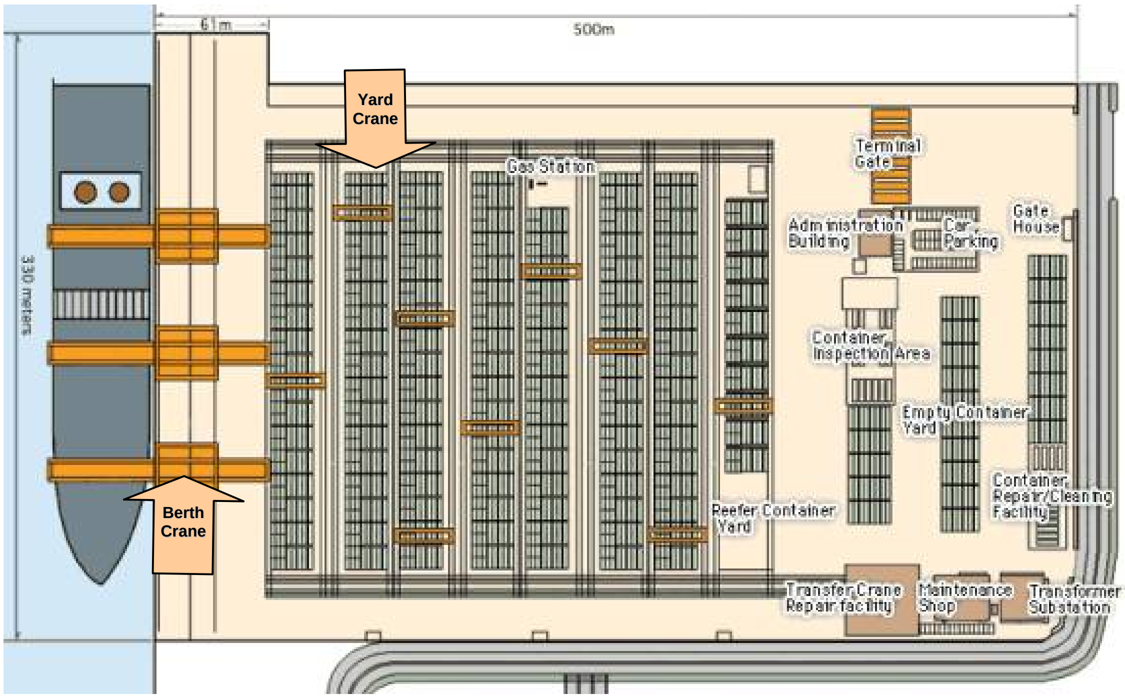
Exhibit 1 - The Logistics Chain



Source: A. Nesathurai – Key Players in the Logistics Chain

A layout of a currently operational single-berth container terminal is shown below, and illustrates the major components of a modern container terminal.

Exhibit 2 – Layout of a Single-Berth Container Terminal



Source: Hakata

A typical container terminal consists of the water-side berth for docking the ships, a large paved yard for storage of containers, specialized cranes, tractors and other equipment for handling the containers from the ship to the storage yards, a computerized gatehouse to control entry and exit of containers from the yard on trucks, and various maintenance and administration buildings. Most container terminals also have a rail yard, also known as the Intermodal Container Transfer Facility (ICTF), for containers transported by rail.

Under normal operations, a container ship – commonly referred to as a "container vessel", would dock alongside the berth. The berth cranes would then unload containers from the vessel onto a yard tractor, which would drive up underneath the berth cranes. The yard tractor would then take the container for storage into the container yard underneath a yard crane, where the container would be off-loaded and placed in a designated storage space in the container yard. By this time the customer has been notified that his container has arrived. At the appropriate time, the customer's truck will enter the container terminal through the gate, drive over to the container yard, where the yard crane will place the container on the truck, and the truck will depart with the terminal with the truck. Alternatively, if there are several containers that are destined for a single location, such as a city, a commercial market area, or manufacturing plant located more than 400 miles away, it is usually more economical to ship these containers on a special "dedicated, double-stack" train to their final destination. This train is loaded at the ICTF adjacent to the container yard in the container terminal.

The following exhibits show a container vessel being unloaded at a container berth, and a loaded double stack train with containers at an ICTF.

Exhibit 3 - Unloading a Container Vessel at a Container Berth

Exhibit 4 - Double Stack Rail Cars at ICTF

Source: PNC

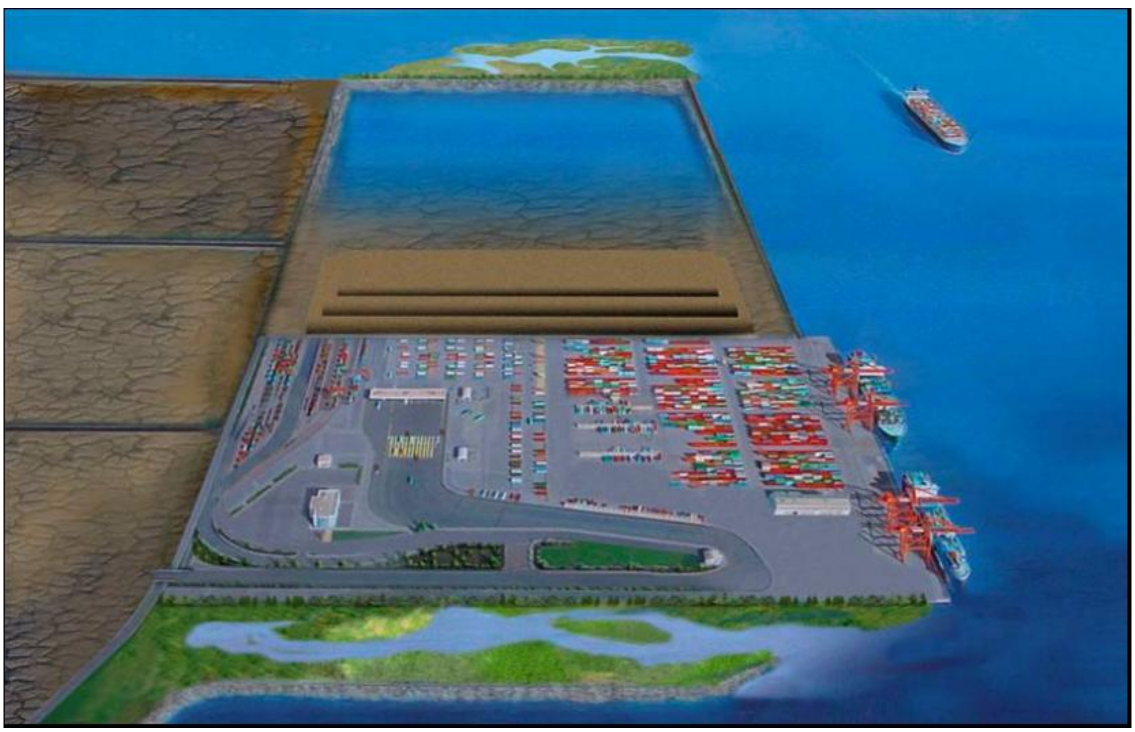
The entire operations is managed and controlled by a computerized Terminal Operating System (TOS) located in the office building, which also houses the administrative and management staff. Additional space in the office building is leased out to port users and government agencies such as Customs and Immigration, or alternatively a separate building is constructed to house the port's users and tenants. Additional buildings for labor locker rooms and cafeteria as well as Custom's inspections, equipment repair and maintenance, and electric and other utilities are also located on the container terminal.

A large warehouse used for "stuffing and stripping" containers, known as a Container Freight Station (CFS) is also usually located on the terminal. Finally, sound planning practice dictates that every port should acquire and set aside a significant amount of undeveloped land adjacent to the terminal for future growth and expansion in cargo, also referred to as a "land bank". There are currently no consistent standards that define the amount of additional land that a port should "land bank" but historically, major U.S. ports have typically acquired as much land adjacent to the port as their budgets would allow, and have frequently acquired land 20 or more years in advance of their anticipated need.

The minimum size for a modern container terminal, regardless of the volume of cargo projected in the initial years of operation, is two berths. Direct liner vessels usually have a fixed schedule for arrival and departure at each port along their itinerary, and will insist upon docking at a berth and commencing cargo operations immediately upon arrival. Any delays regardless of the cause are not acceptable, and will cause the liner vessel to divert to a competitor port. Therefore, in order to remain competitive and provide the level of service demanded by direct liner vessels, any modern container port must have a minimum of two berths, regardless of the volume of cargo.

A model of a new 2-berth container terminal currently under construction in the U.S. South Atlantic for one of the largest container vessel operators in the world today is shown in the following exhibit. While the model shows a layout of a 2-berth container terminal, it is important to note that the port is simultaneously land-filling and developing a "land bank" with more than three times as much acreage as the 2-berth area under construction.

Exhibit 5 - Model of a 2-Berth Container Terminal with Land Bank



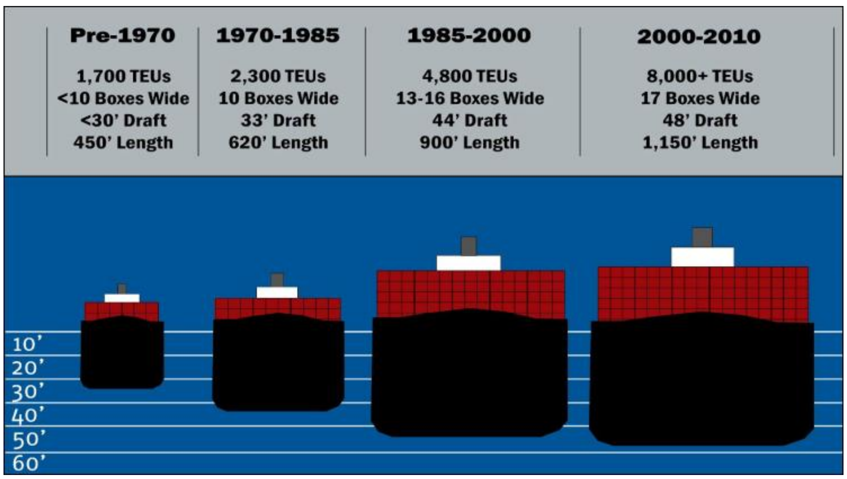
Source: VPA

The size of a container terminal is defined by the length of berth required to service the vessels expected to call at the terminal, and the acreage required to handle the cargo projected for the port. In the following sections we will examine the berth length and the acreage requirements for a 2-berth container terminal.

III. The Vessel Types and Sizes

Container vessels are defined by their capacity to carry containers, measured in Twenty-Foot Equivalent Units (TEU's). The physical size and capacity of container vessels has been doubling every decade, and while the largest vessels currently under construction have the capacity to carry over 12,000 TEU's, by 2015 the largest container vessels will exceed a capacity of 18,000 TEU's. The exhibit below shows how rapidly container vessels have increased in size.

Exhibit 6 – Container Vessel Evolution



Source: VPA

However for the purpose of our analysis, we have assumed that our generic container terminal will be designed to handle direct liner service container vessels in the 6,000 TEU range. These vessels range in size from 5,000 TEU to 8,000 TEU, and are referred to as Post Panamax 5th generation vessels.

The following exhibit shows that while the 5th generation ships currently constitute the majority of the container vessels in service, within the next ten years, these will be overtaken by the next generation of vessels of over 8,000 TEU in size. During this period, it is expected that the 6th generation vessels will replace the smaller vessels in direct liner services, while the 5th generation vessels will perform the role of feeder ships. At a minimum, a new container terminal built in the next decade must have the size and capacity to berth and handle at least the 5th generation, Post Panamax vessels.

Exhibit 7 – World Container Vessel Inventory

Size category (TEU)	Existing fleet		Order book	
	K TEU	Ships	K TEU	Ships
>7,500	402	50	1,464	170
5,000 – 7,499	1,563	269	744	130
4,000 - 4,999	1,195	270	636	145
3,000 – 3,999	905	266	183	55
2,000 – 2,999	1,372	552	464	175
1,000 – 1,999	1,338	947	270	198
100 - 999	5,76	1,027	89	109
All Ships	7,351	3,381	3,850	982

Source: Cornell

Fifth generation container vessels come in three categories – pure container vessels, roll-on roll-off vessels and combination vessels – and are shown in the following exhibits.

Exhibit 8A - Container Vessel

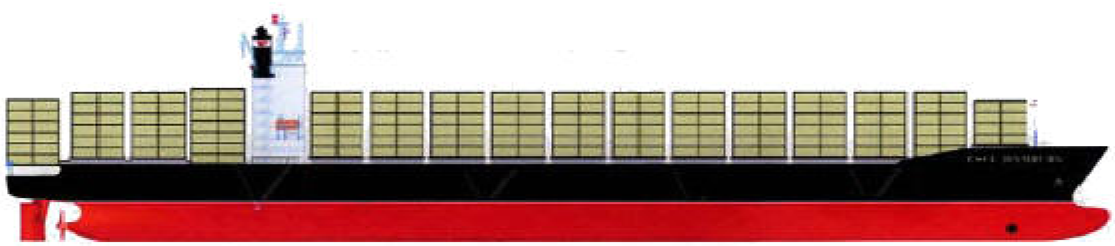


Exhibit 8B - Roll-on Roll-off Vessel

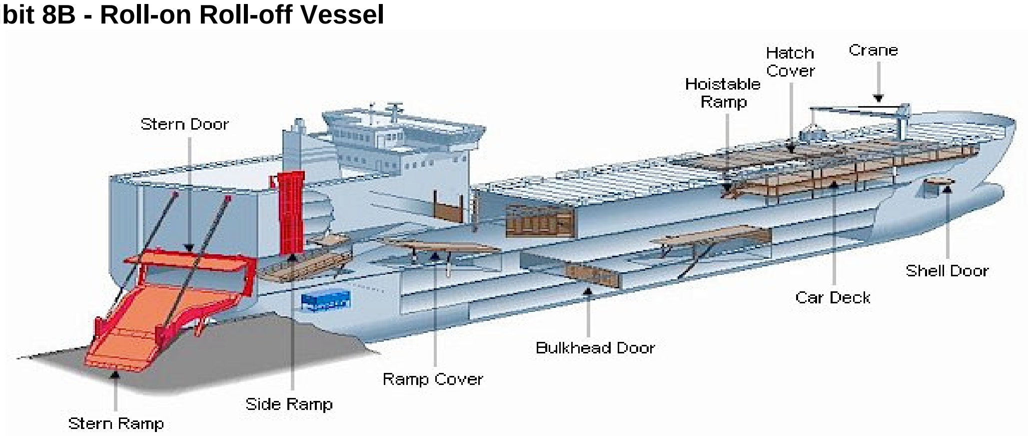
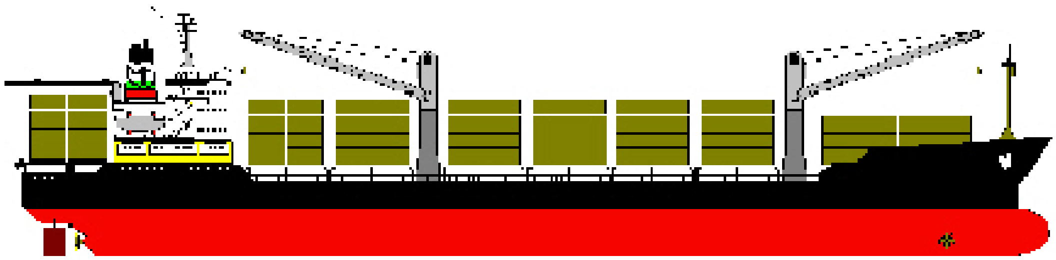


Exhibit 8C - Combination Vessel



The largest of these vessels is the pure container vessel, and measures up to 1,060 feet in length, 141 feet wide and requires a draught of 43 feet. The Ro-Ro vessels and Combination vessels are smaller, but use the same port facilities for loading and unloading cargo. The Ro-Ro vessels carry cargo that can be rolled on and off the vessel such as heavy equipment on rolling platforms, farm equipment, automobiles, pleasure boats, and similar cargo. The combination vessels have containers on the top deck, but within the holds, carry solid types of cargo such as cargo on pallets, boxed cargo, small equipment, paper in rolls or bundles and steel products.

While the generic container terminal is expected to handle Container Vessels, Roll-on Roll-off vessels (Ro-Ro) and Combination container/breakbulk vessels, the berths must be designed for the largest vessel anticipated with dimensions of 1060 feet in length, 141 feet wide and 43 feet of draught.

The length of the dock face for a 2-berth terminal should be adequate to tie up two vessels end-to-end, with about 50 feet of space at each end of the vessel to allow for shifting of the vessels due to swells and tides, and as a safety margin to avoid collision between the two vessels.

Based on these parameters, it is estimated that each berth at a 2-berth terminal will require a length of 1,200 feet and a draught of 44 feet at Mean Low Water (Average low tidal range). The total length of the two berths at the dock face should be 2,400 linear feet with space provided to add an additional 2,400 feet in the future.

IV. Acreage Requirement

One way to determine the acreage requirement for a container terminal at a specific site would be to estimate the projected cargo volume at the port over the next 20 years, measure the dwell time and storage requirements for the cargo, and model the transportation characteristics of the cargo moving in and out of the port.

However our analysis is non-site specific and estimates the acreage required for a generic 2-berth container terminal. For our analysis, we have assumed that the cargo volume projections, cargo operations and storage characteristics would mirror the average cargo handling characteristics for ports across the United States. We assembled the data for seven container terminals at seven major ports in the U.S., evenly distributed with one sample from each part of the U.S. coastline from the East Coast North Atlantic to the Pacific North West, and also included the data from one major Greenfield container terminal in East Asia. To the extent possible, we focused on terminals handling predominantly container cargo, and which provided the total acreage utilized for their container operations on their website. The number of berths was based either on the stated number on the website, or calculated based on the total linear footage of the berths. The results of our survey are shown in Exhibit 8, and indicate that:

- The acreage utilized by container terminals ranges from 45 acres per berth to 73 acres per berth (the large West Coast Port with 80 berths is an exception).
- The Median for all the container terminals surveyed is around 61 acres per berth.

Exhibit 9 – Survey of 7 U.S. and 1 Asian Container Terminal

Port	Berths	Acres	Acres/Berth
U.S. North Atlantic	4	178	44.50
U.S. Mid-Atlantic	3	219	73.00
U.S. South Atlantic	4	193	48.25
U.S. Gulf	7	378	54.00
U.S. West Coast	80	3200	40.00
U.S. Pacific North West #1	2	135	67.50
U.S. Pacific North West #2	3	220	73.33
East Asian Greenfield Terminal	9	640	71.11
Median Acres Per Berth			**60.75**

In addition, our survey also indicated that ports set aside a 'land bank' for future expansion of container terminals and other cargo, which can range from 300% of the current acreage of the existing terminal to over several thousand percent of the existing terminal acreage. The exhibit below illustrates the "land banking" acquisition practices of three U.S. Atlantic coats and one U.S. West Coast Port. The acreage information in this exhibit is broadly estimated and based on interviews with port experts.

Exhibit 10 – Land Banking Acquisition Practices of Selected U.S. Ports

Port	Estimated Operational Acreage	Estimated Additional Acreage Acquired for Land Bank
Port A	940+acres	3,000+acres
Port B	700+acres	2,100+acres, including two islands and a converted U.S. Navy base
Port C	1,100+acres	Acquired land as well as created land through landfill for Greenfield terminal
Port D	3,000+acres	Acquired and converted a U.S. Naval Station

In the event the area under consideration for port development is adjacent to public recreational use or residential areas, there will also be a need to set aside a “buffer zone” which can visually and audibly shield the public from the activities at the container terminal. For a 2-berth terminal, it is estimated that this buffer zone would require at least 14 acres, and possibly more space based on the topology of the area.

Using the median of 61 acres per berth and the higher alternative of 73 acres per berth, and including a buffer zone of 14 acres, we estimate that a 2-berth container terminal would require a minimum of 136 acres and up to 160 acres of land for development of a container terminal. In addition, if a minimum of 100% of the estimated acreage is set aside for a ‘land bank’[1], as is the practice at most ports, the acreage requirement is a minimum of 272 acres, and can be up to 320 acres.

This estimated acreage of 272 acres to 320 acres assumes a best-case scenario with a flat, rectangular, contiguous area available for development, and a linear, sheltered coastline. Clearly, any changes to these conditions would adversely affect and increase the total acreage required to develop an efficient container terminal with world-class productivity.

Exhibit 11 – Estimate of Acreage Required for a 2-Berth Non-Site Specific Container Terminal

Generic Container Terminal	*Specifications*
Berths	2
Median Acres per Berth	61
Alternative Acres per Berth	73
Buffer Zone Acres for 2 Berths	14
Total Median Berth Acreage	136
Total Alternative Berth Acreage	160
Acreage With Land Bank for 2-berth Expansion - Median	272
Acreage With Land Bank for 2-berth Expansion - Alternative	320

[1] The U.S. Maritime Administration (MARAD) implicitly supports acquisition of land by ports though its Port Facility Conveyance Program.

MARAD administers a public-benefit conveyance program that transfers surplus federal real property to state and local public entities for the development and operation of port facilities. The purpose of the program is to create jobs, revitalize local economies, and increase maritime port capacity to meet the nation's commerce and defense needs. Conveyances involve no monetary consideration provided the property is used and maintained in perpetuity as a port facility.